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(54) Title of Invention: **PRINTED CIRCUIT BOARD WITH THICK FILM ELEMENT**

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SPECIFICATION

1. Title of Invention

Printed Circuit Board with Thick Film Element

2. Claim

A printed circuit board with a thick film element that is a printed circuit board comprising

an insulation layer composed of a ceramic, resin, or composite material thereof on a base material made of a metal, ceramic, resin, or composite material thereof and

a conductor circuit which is generated on the insulation layer, wherein

a resistance element or capacitor element formed by a thick film process is embedded between said conductor circuit and said insulation layer.

3. Detailed Description of the Invention

[Field of Industrial Utilization]

The present invention relates to a circuit board with a thick element obtained by printing or the like. This type of printed circuit board is used in a broad range of fields in the electronic industry as used in vehicles, computers, communication devices, or in mixed circuits for OA (office appliance) and the like.

[Conventional Technology]

Because of their many advantages such as the ability for the miniaturization of elements, the effective utilization of the limited area of a substrate, the ease of generating an electrical connection between an element and the conductor circuit and the like, printed circuit boards that have resistor or capacitor thick film elements or the like are extensively used in many areas.

A general manufacturing procedure for a printed circuit board having such a thick film element, as illustrated in Figure 3, calls for coating a printing paste by screen printing onto the desired location of a conductor circuit, preformed on an insulation layer, and then firing at a temperature of about 900°C, thereby forming a printed element.

However, since the base material and insulation layer material in such a manufacturing process has had to withstand the above firing temperature, both materials had to have been made of ceramics. Therefore, there have been disadvantages that had to be tolerated, such as higher material costs compared to a resin material, complicated fabrication processes, poor electrical properties, the difficulty in achieving high density wiring, and the like. It is also known that, for example, the use of a carbon resin type printing paste as disclosed in Japanese Patent Application Publication Kokai 59-138304 enables one to generate a printed element on a relatively low heat resistance material. However, in contrast to the ceramic base materials used in the high temperature fired printing paste, the carbon resin print paste uses a

resin base material, resulting in deficiencies such as low moisture resistance reliability and higher TCR values; and a higher coefficient of expansion?[friction] causing an increased drift in the presence of heat, lower heat dissipation causing the standard electrical power to be lower, and weakness to impact from the outside.

Technologies for embedding an element between the conductor circuit and the insulation layer have already been invented, including a manufacturing process disclosed in Japanese Patent Application S56-11204. Said process is " A process for manufacturing a flattened metal foil resistance circuit board using an aluminum substrate: comprising the steps of

generating a thermoset resin adhesion layer on one side of an aluminum sheet 2mm or less thick ,

placing a metal foil on said adhesion layer, followed by applying heat and pressure for integration,

applying the usual method of photo printing or screen printing-etching said metal foil, thereby generating a metal foil resistance circuit board based on the aluminum sheet substrate as the desired metal resistance circuit,

overlaying a moisture resistant cushioning material on the side of said metal foil resistor circuit board that lacks the metal foil resistor circuit,

clamping this [assembly] between platens with heat and pressure to sink said metal foil resistor circuit into said thermoset adhesive layer, and

removing said cushioning material.

Said invention makes it possible to obtain a compact structured substrate which has been difficult to obtain conventionally. However, in general, it is difficult to make a metal foil resistor having a high resistance value, which makes them unsuitable for a "pull up" high resistor in a digital circuit. Since different metals are used as the conductor metal material and the metal foil resistor material, the application of heat generates a thermo-electromotive force presenting the high possibility of causing an offseting shift in analog circuits. In addition, in such a conventional process, because the side lacking the

metal foil resistor circuit ultimately protrudes, this makes it difficult to generate a completely flattened substrate, causing the cost to rise.

[Problem to be Solved by the Invention]

The present invention, made in view of the above circumstances, addresses the task of completely eliminating the imperfections of the prior art as discussed above, and is aimed at providing a compact printed circuit board incorporating a high resistivity, highly reliable thick film element.

[Means Used to Solve the Problem]

The means used in this invention to solve the above problems is explained in reference to Figures 1 and 2, which correspond to the working examples of this invention to be described later.

"A printed circuit board with a thick film element that is a printed circuit board comprising

an adhesive layer (11) composed of a ceramic, resin, or composite material thereof on a base material(11) made of a metal, ceramic, resin, or composite material thereof and

a conductor circuit(13) which is generated on the adhesive layer(12), wherein

a resistance element or capacitor element formed by a thick film process is embedded between said conductor circuit(13) and said adhesive layer(12)."

That is, the printed circuit board (10) of this invention has a thick film element generated by a printing method or a dispenser method. Since the element (14) is a high precision, high temperature firing type element which is used in ceramic substrates, it has greater reliability compared to that of the carbon resin printed element; in addition, it is embedded in the insulation layer, thereby making it possible to carry out a compact design and to provide a structure which can sufficiently improve mechanical strength as well.

Such a printed circuit board can also be made into a 2-side printed circuit board by conducting through the front and the back sides by through-holes; it is also possible to implement the invention with a so-

called multi-layer printed circuit board by laminating a plurality of layers.

The present invention is further described in detail.

The high temperature firing type thick film paste used in this invention permits using a resistor paste such as RuO_2, LaB_4 [illegible subscript], SnO_2, or TaN and the like, and a capacitor paste such as barium titanate or titanium oxide or the like. In particular in considering coating onto metal foil and firing at a high temperature, it is preferred to fire under nitrogen or nitrogen + hydrogen to prevent metal oxidation so that it is preferred to use an LaB_4 [illegible subscript]type SnO_2 type or a TaN type. Then the metal foil for the coated substrate which can be used includes Cu, Al, Ni, Fe, or an alloy of these metals, preferably Cu is used in view of its workability in later steps. The thickness of the metal foil, in view of coating workability and post-step processability, is preferably selected from the range 0.01-0.1mm.

The base material (11) that can be used includes metallic materials such as Al, Cu, Ni, Fe, or an alloy thereof or a clad material such as Cu-In-Cu, ceramic materials such as alumina, AlN, SiC, or BeO or the like, and resin materials such as epoxy resins, polyimide resins, phenolic resins, and the like. Each of these base materials (11) can be individually used, depending on the required properties or application such as a metallic material if heat dissipation is needed or a ceramic material if heat resistance is required.

The adhesive material used in the adhesive layer (12) must be able to adhere the metal foil on which an element (14) is printed to the base material (11) and at the same time must be electrically insulating. The most exemplary material which meets such properties is a glass[fiber glass?]-epoxy system where in addition, one may also use a resin type adhesive such as a glass-triazine, a glass-polyimide, and the like, or a ceramic type adhesive. The thickness of the adhesive layer (12) is preferably between 0.05 and 0.2mm. Obviously, the adhesive used must be selected by considering overall properties such as size, stability, heat conductivity, specific weight, mechanical strength, cost, and the like.

[Advantageous Effect of the Invention]

In the printed circuit board (10) of this invention constructed in the above manner, the use of a high temperature firing type thick film element (14) allows suitably selecting from a low resistance to a high resistance in resistance value; thus it can be satisfactorily used as an element (14) both in analog and digital circuits, in addition, it gives a high precision resistance. Since the thick film paste is directly fired at high temperature on the metal foil which becomes the electrode for the element, the joining of the electrode to the element itself can be stabilized thermally, electrically, and also mechanically. In particular, the use of a metal foil with an anchoring configuration as in the element of the copper foil used in a copper clad laminated sheet is also effective in terms of the stability of the above joint. The conductor circuit (13) is made of metal foil so that it gives good electrical properties. In addition, said thick element (14) is embedded within the adhesive layer (12) so that the surface of the printed circuit board (10) is flat, except for the conductor circuit (13) step(s); hence there is no hindrance to the mounting of an electronic part on the printed circuit board (10), which enables a high density mounting of electronic parts.

[Examples]

Example of this invention are now described in reference to the drawings.

A printed circuit board (10) having a printing element (14) shown in Figure 1 was prepared as follows.

Resistance pastes, 100Ω, 10kΩ, and 100kΩ (produced by DuPont Company, under the trade name QP-60) were each screen printed onto a 70μm thick copper foil, followed by firing at the firing temperature 900°C for a firing time of 10 minutes in a nitrogen (N_2) atmosphere. Then this was laminated and adhered to a 1.0mm thick aluminum sheet via a 100μm thick [fiber]glass epoxy adhesion sheet (which is a so-called prepreg, corresponding to the adhesion layer (12)) so as to embed the printing element (14) within the adhesion layer (12) to give a copper clad laminate. The desired conductor circuit (13) was obtained by fabricating the copper clad laminate sheet by the usual subtractive process.

Comparative Examples

Fabrication of comparative examples given in Figure 3 is explained below.

A 100Ω, 10kΩ, or 100kΩ resistance paste (produced by Asahi Kagaku KK) was screen printed onto the designated position of the printed circuit board (10), followed by hardening at the hardening temperature 170°C and hardening time of 60 minutes to generate a printed circuit board with the desired resistor print.

The Examples of this invention and the comparative examples prepared as above were evaluated by the method given below and the results are shown in the table below. In the Table, "Percent change in resistance" and "TCR values" were determined under the following conditions:

(1) Percent Resistance Change

The resistance value after a sample was held for 1000 hours at an environment temperature of 150°C was measured by an LCR meter and the change from the initial resistance value was used to compute the percent resistance change.

(2) TCR

Heating was started at room temperature to measure the resistance value every 20°C by an LCR meter from which a TCR that is, a slope was obtained.

Table

	Resistance (Ω)	Percent Change in Resistance (%)	TCR (ppm/°C)
Examples of this Invention	100	±1.0	±100
	10k	±1.0	±100
	100k	±1.0	±100
Comparative Example	100	±20	-300
	10k	±30	-500

	100k	±40	-600

[Advantageous Effect of the Invention]

As described in detail, the printed circuit board with a thick film element according to this invention is characterized by its construction as illustrated in these examples as

"A printed circuit board with a thick film element that is a printed circuit board comprising

an insulation layer composed of a ceramic, resin, or composite material thereof on a base material made of a metal, ceramic, resin, or composite material thereof and

a conductor circuit which is generated on the insulation layer, wherein

a resistance element or capacitor element formed by a thick film process is embedded between said conductor circuit and said insulation layer".

Therefore, the invention provides a compact printed circuit board incorporating a high precision, high reliability thick film element.

In the printed circuit board (10) having a thick element (14), of this invention, the thick film element (14) is a high precision, high firing type so that it not only has high precision and high reliability, but it also offers a broad range of resistance values that can be selected, to make it suitable to meet any circuit requirements. In addition, selecting the [right]type of paste material (11) can satisfy the required properties thereby providing a printed circuit board (10) with an excellent cost-performance balance.

In addition, according to this invention, the thick film element (14) is embedded within the adhesive layer (12) so that the surface of the printed circuit board (10) is flattened to enable mounting electronic parts on the thick film element (14) as well making the print circuit board (10) of this invention also suitable for high density mounting.

4. Brief Description of the Drawings

Figure 1 is a perspective view of a printed circuit board with a thick film element according to this invention; Figure 2 is a partial

expanded cross-sectional view thereof; Figure 3 is a partial expanded cross-sectional view for a prior art example.

Figure 1

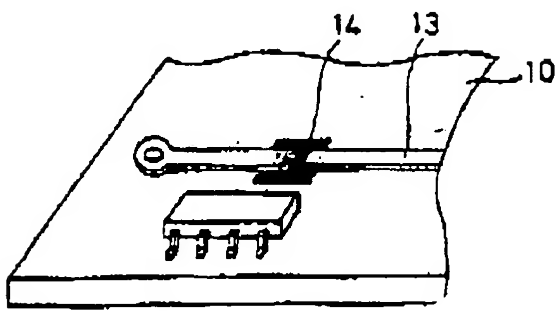


Figure 2

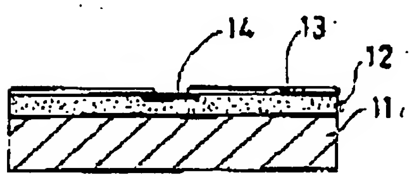
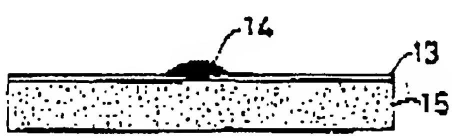


Figure 3



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